TITLE OF THE INVENTION

GUIDANCE INFORMATION PROVIDING APPARATUS, SERVER APPARATUS, GUIDANCE INFORMATION PROVIDING METHOD, AND PROGRAM PRODUCT

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of priority from the prior Japanese Patent Applications No. 2002-378447, filed December 26, 2002; and No. 2003-423977, filed December 22, 2003, the entire contents of both of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a guidance information providing apparatus, server apparatus, guidance information providing method, and program for providing guidance information.

2. Description of the Related Art

Recently, a guiding apparatus for guiding a user from a departure place to a destination is beginning to be generally used. Although the most typical example is a car navigation system, a guiding apparatus for a walker is also implemented in some forms.

For example, a guidance service based on user's position information is performed for a portable terminal containing a GPS (Global Positioning System) receiver. Also, a service with which a user can see an

information map by explicitly designating a departure
place and destination without using any position
information as described above is provided by PC
software or across the Internet. In these services, a

5   guiding route is automatically generated by searching
road network data purchased from a map company.

Unfortunately, network data is unprepared for
buildings such as stations and underground malls, so no
such guidance services as performed for roads outside

10   such buildings are often performed. A service which
presents cars and doors which stop near stairs to a
user's portable terminal is performed in some stations.
However, this service shows only a limited range by a
prepared sentence and hence is unsatisfactory to guide

15   a user over a broad range such as a large station or
underground mall having a number of floors.

In addition, photographs showing surface views are
posted at some ticket gates of subways. Also, a system
which guides a user by pasting or interpolating a

20   plurality of photographs of views of precincts is also
developed. However, photographs are temporizing
information, so it is difficult for a user to
understand the whole image of precincts or a route to
the destination.

25   On the other hand, the web site of a railroad
corporation presents a three-dimensional information
map of the station precincts drawn by an illustrator.

This information map is subjected to three-dimensional deformation processes of, e.g., shifting upper and lower floors and omitting ceilings. Therefore, a user can understand portions which may be hidden in a simple information map. However, this information map drawn by an illustrator is merely a single picture, so a viewpoint position cannot be changed in accordance with a departure place and destination designated by a user.

To solve this problem, it is necessary to accumulate data representing the three dimensional shapes of the precincts of a building in a computer, and dynamically generate an information map in accordance with a departure place and destination designated by a user. However, if the shapes of the precincts are simply three-dimensionally presented, a guiding route is often hidden by obstacles or upper floors. To present a readily understandable information map, therefore, a computer must perform deformation processes similar to those performed by an illustrator.

Many such three-dimensional deformation techniques are described in the conventional patent (Jpn. Pat. Appln. KOKAI Publication No. 2001-273526) of a car navigation system. Examples are a method of extracting an obstacle covering a guiding route and omitting this obstacle or presenting it as a semitransparent object, a method of changing the color

or texture of an obstacle, a method of presenting only
the contour of an obstacle by using dotted lines, a
method of changing the size or height of an obstacle, a
method of presenting an obstacle by switching it to an
icon or character string, a method of presenting an
obstacle by flickering it, and a method of forcedly
presenting an obstacle at the back of a route.
However, different from roads as objects of car
navigation systems, many "layers" are present in the
precincts of a building. This makes it difficult to
add effective deformation processes only by using the
conventional techniques.

Also, the sky over the present location is used as
a viewpoint in many car navigation systems. In
guidance of the precincts of a building, however, a
readily understandable information map can be obtained
when a viewpoint from which a user can easily
understand ups and downs such as stairs and escalators
is selected. Also, when a viewpoint from which a
guiding route is not so often obstructed by upper
floors is chosen, the amount of deformation processes
reduces, so an information map close to an actual view
can be obtained. For example, a viewpoint from which
the whole three-dimensional shape is clearly seen can
be determined in the technique disclosed in P. Vazquez,
M. Feixas, M. Sbert, and W. Heidrich, "Viewpoint
Selection using Viewpoint Entropy", VISION, MODELING,

AND VISUALIZATION 2001, Stuttgart, Germany, November 21-23, 2001.

Unfortunately, it is difficult for the above-mentioned technique to determine a viewpoint from which ups and downs of a guiding route are readily understandable, or a viewpoint from which a guiding route is not obstructed by upper floors.

BRIEF SUMMARY OF THE INVENTION

The present invention has been made in consideration of the above situation, and has as its object to provide a guidance information providing apparatus, server apparatus, guidance information providing method, and program product capable of more effectively providing information concerning a guiding route.

The present invention may provide a guidance information providing apparatus which comprises: a first memory which stores network data including line segment data representing a passage in a target area of route guidance in an information map and point data representing a connecting point of the passage; a second memory which stores three-dimensional shape data representing a three-dimensional shape of the target area; an input unit which inputs a departure place and destination; a guiding route search unit which searches the first memory to acquire a guiding route connecting the input departure place and destination, on the basis

of the network data; a viewpoint setting unit which sets a plurality of viewpoint position candidates for visualizing the guiding route in the target area expressed in the three-dimensional shape data; an evaluation unit which obtains an evaluation value of visibility, from each of the viewpoint position candidates, of the guiding route in the target area expressed in the three-dimensional shape data; an information map generating unit which generates the information map by determining a viewpoint position for generating the information map from the plurality of viewpoint position candidates on the basis of the evaluation value of visibility and by projecting the three-dimensional shape data from the determined viewpoint position; and a presentation unit configured to present the generated information map to a user.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

FIG. 1 is a view showing the arrangement of an information map presenting apparatus according to the first embodiment;

FIG. 2 is a flow chart showing an example of the flow of processing in the first embodiment;

FIGS. 3A to 3F are views showing examples of images for inputting a departure place and destination in the first embodiment;

FIGS. 4A to 4C are views showing an example of a precinct network in the first embodiment;

FIGS. 5A to 5C are views showing an example of a guiding route in the first embodiment;

FIG. 6 is a flow chart showing an example of the flow of a process of obtaining viewpoint position candidates in the first embodiment;

FIG. 7 is a view showing an example of a first viewpoint position in the first embodiment;

FIG. 8 is a view showing an example of an ith viewpoint position in the first embodiment;

FIGS. 9A and 9B are views showing an example of an ith gazing position in the first embodiment;

FIGS. 10A and 10B are views showing an example of a triangular mesh structure in the first embodiment;

FIG. 11 is a view showing the example of the triangular mesh structure in the first embodiment;

FIG. 12 is a view showing the example of the triangular mesh structure in the first embodiment;

FIG. 13 is a view showing examples of route surfaces in the first embodiment;

FIGS. 14A and 14B are views showing examples of route surfaces in the first embodiment;

FIG. 15 is a flow chart showing an example of the flow of processing performed by an information map generating unit 9 of the information map presenting apparatus according to the first embodiment;

FIGS. 16A and 16B are views showing examples of precinct information maps in the first embodiment;

FIG. 17 is a view showing the arrangement of an information map presenting apparatus according to the second embodiment;

FIG. 18 is a flow chart showing an example of the flow of processing in the second embodiment;

FIGS. 19A and 19B is an example of deformation procedure to delete a portion which obstructs the guiding route;

FIGS. 20A and 20B are an example of deformation procedure to delete extra floors from the three-dimensional shape of precincts;

FIGS. 21A and 21B are an example of deformation procedure to delete extra region from the three-dimensional shape of precincts;

FIGS. 22A and 22B are an example of deformation procedure to move a floor which obstructs a guiding route in the three-dimensional shape of precincts;

FIGS. 23A and 23B are an example of deformation procedure to rotate a floor which obstructs a guiding route in the three-dimensional shape of precincts;

FIGS. 24A and 24B are an example of deformation procedure to curve a floor which obstructs a guiding route in the three-dimensional shape of precincts;

FIGS. 25A and 25B are an example of deformation procedure to rotate a floor including a guiding route far from a viewpoint in the three-dimensional shape of precincts;

FIGS. 26A and 26B are an example of deformation procedure to curve a floor including a guiding route far from a viewpoint in the three-dimensional shape of precincts;

5   FIG. 27 is a view showing the arrangement of an information map presenting apparatus according to the third embodiment;

FIG. 28 is a flow chart showing an example of the flow of processing in the third embodiment;

10   FIG. 29 is a view showing the arrangement of an information map presenting apparatus according to the fourth embodiment;

FIG. 30 is a flow chart showing an example of the flow of processing in the fourth embodiment;

15   FIG. 31 is a flow chart showing an example of the flow of processing in the fifth embodiment;

FIGS. 32A and 32B are an example of a function of adding a supplementary explanation according to the fourth embodiment; and

20   FIGS. 33A and 33B are an example of a function of generating information maps split the start point or end point of a partial route.

DETAILED DESCRIPTION OF THE INVENTION

The first to eighth embodiments of the present
25   invention will be described below with reference to the accompanying drawing.

(First Embodiment)

The first embodiment of the present invention will be described below.

This embodiment will be explained by taking a station as an example of a guidance target area (e.g., precincts such as a station, underground mall, building, event site, amusement park, or zoo, or a predetermined range of a city) as an object of a service for performing route guidance by presenting an information map, and taking an information map of station precincts as an example of the information map.

FIG. 1 shows the arrangement of an information map presenting apparatus according to this embodiment.

As shown in FIG. 1, the information map presenting apparatus of this embodiment comprises an input unit 1, network storage unit 7, route search unit 4, shape storage unit 8, viewpoint selecting unit 10, information map generating unit 9, presentation unit 3, and controller 2.

The input unit 1 is a device for inputting a departure place and destination as objects of guidance in, e.g., precinct guidance. Although it is explaining inputting the departure place and the destination here, it may be inputting other parameter, such as not only the departure place and the destination but a view angle which saw the destination from the departure place or a map of size. The network storage unit 7

stores network data representing passages in precincts
or the like. The route search unit 4 searches the
network storage unit 7 for a guiding route connecting a
departure place and destination. The shape storage
unit 8 stores polygon mesh data representing the
three-dimensional shape of a guidance target area as an
object of guidance such as precincts. Although it is
explaining storing polygon mesh data here, it may be
storing a data of other expression methods, such as not
only the polygon mesh data but a curved surface. The
viewpoint selecting unit 10 selects candidates of
viewpoint positions to be set in the three-dimensional
space on the basis of the guiding route found by the
route search unit 4. A viewpoint evaluation unit 6
evaluates (e.g., quantitatively) the visibility of the
guiding route from the viewpoint position selected by
the viewpoint selecting unit 10. The information map
generating unit 9 generates an information map such
as a precinct information map by projecting the
three-dimensional shape of, e.g., precincts from the
viewpoint position which is evaluated to give the best
view of the precincts by the viewpoint evaluation unit
6. The presentation unit 3 presents a user with the
three-dimensional information map of the precincts or
the like generated by the information map generating
unit 9. The controller 2 controls the operation of
each unit.

Note that this information map presenting apparatus can be constructed as an apparatus including the whole configuration described above, or as a server-client system in which a server apparatus contains part of the above configuration (and a transmitting/receiving function of communicating requests and information maps across a network), a client apparatus contains the rest of the configuration (and a transmitting/receiving function of communicating requests and information maps across a network), and these client apparatus and server apparatus are connected across a wired or wireless network. In the former case, the information map presenting apparatus may also be constructed as a totally standalone apparatus. Alternatively, the information map presenting apparatus can be so designed as to have a function of connecting to a network and a function of downloading necessary information (e.g., the latest versions of various data). In the latter case, various dispersion methods are possible. For example, the input unit 1 and presentation unit 3 are incorporated into the client apparatus, and the rest is incorporated into the server apparatus. The client apparatus can also be a dedicated terminal. For example, a PC or cell phone terminal can be used. These respects apply to the second to sixth embodiments to be described later.

FIG. 2 shows an example of the processing sequence of the information map presenting apparatus of this embodiment.

In step S101, a user uses the input unit 1 to input a departure place and destination of precinct guidance. Note that the departure place need not be the present position (e.g., a point other than the present position can be set as a departure place, and the present position can be set as a destination). Examples of devices usable as the input unit 1 are a touch pen, a touch panel, a mouse, operation keys such as buttons, a microphone for inputting voices, and a device which communicates with a user's portable terminal.

FIGS. 3A to 3F show an example of a user interface for performing the input process.

In this example, an image as shown in FIG. 3A which includes four input forms, two search buttons, one reset button, and a "Display" button for displaying an information map is displayed as an initial image. When the user designates a keyword related to the departure place (e.g., when the user inputs "S station, T line" and touches the search button as shown in FIG. 3B), a list of keyword-related places in the station precincts is displayed (e.g., a list is displayed as shown in FIG. 3C). Therefore, the user selects one of these places.

In FIG. 3C, seven candidates such as "T line,
South gate" are displayed for the designated keyword "S
station, T line", and the user selects the present
position, i.e., "Platform 2 (bound for A)" as a
5   departure place.

The destination can be input in the same manner as
for the departure place. For example, when the user
inputs the keyword "S station, T line" and touches
the search button as shown in FIG. 3D, a list of
10   keyword-related places in the station precincts is
displayed as shown in FIG. 3E. Therefore, the user
need only select, e.g., "Y line, Outer tracks, Platform
1 (bound for B)". When the departure place and
destination are completely input as shown in FIG. 3F,
15   the user touches the "Display" button in the lower
portion of the screen, and the flow advances to next
processing.

The user interface for inputting the departure
place and destination is, of course, not limited to the
20   example shown in FIGS. 3A to 3F, and various other
methods are possible. Examples are an input method
using hierarchical menus corresponding to different
types of places, e.g., a platform, doorway, gate,
ticket office, and rest room, an input method using
25   voices, and an input method which communicates with a
user's portable terminal. It is also possible to
automatically determine a departure place by receiving

position data from a position providing device installed at a branching point in the precincts or at the entrance of a room by using short-range radio communication such as Bluetooth (TM). Alternatively, one or both of a departure place and destination can be automatically determined by interlocking the information map presenting apparatus with the existing train changing service. Furthermore, if the information map presenting apparatus is installed in the station precincts, it is also possible to input only a destination by omitting inputting of a departure place.

As the method of inputting a departure place and destination, it is also possible to display a map image including the whole or part of a range as a departure place or destination, and allow a user to input a desired portion on the map image as a departure place or destination by using, e.g., a mouse or touch panel. The user can also input a number displayed in a predetermined portion on the map image as a departure place or destination. That is, various other methods can be used.

A description will return to the explanation of the flow chart shown in FIG. 2.

In step S102, the route search unit 4 searches the network data stored in the network storage unit 7 for a guiding route connecting the departure place and destination.

In this practical example, the network data is
precinct network data. As shown in FIG. 4A,
the precinct network includes line segment data
representing passages in the precincts, and point data
5   representing connecting points of the line segment
data. For example, the point data exists at a
branching point of the line segment data, at the
position of a landmark, or at the position of a
candidate of the departure place or destination of
10   precinct guidance. Note that these line segment data
and point data are stored in forms as shown in FIGS. 4B
and 4C, respectively, in the network storage unit 7.

The route search unit 4 extracts from this network
a portion corresponding to the guiding route connecting
15   the departure place and destination. In this
processing, it is possible to use, e.g., a Dijkstra's
algorithm known as a method of obtaining a minimum-cost
route on a network. Note that the total distance of a
route is generally used as the cost of the Dijkstra's
20   algorithm. In addition, the cost may also be changed
by adding the number of corners included in the route
or the sizes of ups and downs such as stairs and
escalators.

For example, a guiding route as shown in FIG. 5A
25   is generated as a result of the application of the
Dijkstra's algorithm. FIG. 5A shows an example of a
guiding route which starts from point data No. 23 and

ends at point data No. 10 via point data Nos. 21, 20, and 13 in this order. This guiding route includes line segment data shown in FIG. 5B and point data shown in FIG. 5C. FIG. 5B shows line segment data on the route extracted from FIG. 4B. FIG. 5C shows point data on the route extracted from FIG. 4C.

A description will return to the explanation of the flow chart shown in FIG. 2.

In step S103, a viewpoint position is selected by the viewpoint selecting unit 10.

This selection will be explained by taking a method of selecting viewpoint positions in turn from previously obtained viewpoint position candidates as an example.

FIG. 6 shows an example of a processing sequence of obtaining viewpoint position candidates.

In first step S201, a first viewpoint position ViewPoint_1 is calculated by

$$\text{ViewPoint\_1} = \text{Mid} + ((\text{Distance}/\cos\theta \times \text{Back}) \qquad (1)$$

where Mid indicates the three-dimensional coordinates of a midpoint of a line segment connecting the departure place and destination, Distance is the length of this line segment connecting the departure place and destination, and Back is a unit vector indicating a backward and upward angle θ when the destination is viewed from the departure place. As the value of θ, 30° which is often used in a bird's-eye view of a car

navigation system can be designated. Alternatively,
the value of θ can be input from the input unit 1 by
the user. Note that a point immediately below
ViewPoint_1 is represented by U_1. Individual
parameters are as shown in FIG. 7.

In step S202, a first gazing position Look_1 is
calculated by equation (2) to be presented later. A
method of calculating this gazing position will be
explained as calculation of an ith gazing point in step
S206.

In step S203, a suffix $\underline{i}$ and rotational angle γ
are initialized.

In step S204, whether the rotational angle γ is
360° or less is determined. If the rotational angle γ
is 360° or less, the flow advances to step S205. If
the rotational angle γ is larger than 360°, this
process of obtaining viewpoint position candidates is
terminated. In this determination in step S204,
candidates are determined in accordance with whether
the rotational angle γ is 360° or less. However,
the present invention is not limited to this method.
For example, the determination may also be made by
using another value as the rotational angle γ. It
is also possible to determine candidates from a
three-dimensional range by introducing, e.g., a solid
angle or a direction such as a height, in addition to
the rotational angle γ.

In step S205, an ith viewpoint position ViewPoint_i and a point U_i immediately below that are calculated by rotating the first viewpoint position ViewPoint_1 through $\gamma°$ around Mid. FIG. 8 illustrates this processing.

In step S206, a gazing position Look_i corresponding to each viewpoint position ViewPoint_i is calculated by

$$Look\_i = \alpha \times Near\_i + \beta \times Far\_I \qquad (2)$$

where Near_i is the foot of perpendicular extended from a point P_i on a route closest to ViewPoint_i to a straight line connecting U_i and Mid, and Far_i is the foot of perpendicular extended from a point Q_i on a route farthest from ViewPoint_i to the straight line connecting U_i and Mid. FIG. 9A shows Near_i and Far_i. Also, α and β are positive constants which satisfy $\alpha + \beta = 1$. As shown in FIG. 9B, Look_i represents a point which internally divides Far_i and Near_i at $\alpha : \beta$.

In step S207, the suffix i is incremented by 1, and the rotational angle θ is increased by $\phi°$. After that, the flow returns to step S204. In this manner, viewpoint positions and gazing positions when they are rotated 360° step by step at $\phi°$ around the guiding route are calculated.

In step S103 of FIG. 2, an arbitrary one of the viewpoint position and gazing position candidates thus

calculated is selected.

In step S104, the viewpoint evaluation unit 6 calculates the visibility of planes (route surfaces) arranged along the guiding route, thereby quantita-tively evaluating the visibility of the guiding route.

The route surfaces are arranged by extracting a portion including the guiding route from the three-dimensional shape (in this example, the three-dimensional shape of the precincts) of the guidance target area stored in the shape storage unit 8, and referring to the shape of this portion.

For example, the three-dimensional shape of the precincts is represented by a triangular mesh structure as shown in FIG. 10A. The triangular mesh structure is a data structure including points each representing three-dimensional coordinates, line segments each connecting two points, and triangles each connecting three line segments counterclockwise. Referring to FIG. 10A, points ID are indicated by usual numbers, and triangles ID are indicated by numbers enclosed with circles. Assume that data of the points, line segments, and triangles are stored in forms as shown in FIGS. 10B, 11, and 12, respectively, in the shape storage unit 8.

From this triangular mesh, the viewpoint evaluation unit 6 finds triangles crossing line segments forming the guiding route. The viewpoint

evaluation unit 6 generates planes having the same normal vectors as those of the found triangles, and arranges these planes with an appropriate width such that the line segments are central lines of these planes. FIG. 13 shows this processing. However, if a triangle positioned below a line segment is a portion of a stairway or escalator, the viewpoint evaluation unit 6 generates two planes having normal vectors NL and NR perpendicular to the normal vector of the triangle. FIGS. 14A and 14B illustrate two route surfaces FL and FR. FIG. 14A shows the front view of the stairway or escalator, and FIG. 14B shows the left and side views of the stairway or escalator. Referring to FIG. 14A, the two route surfaces FL and FR have a thickness for the sake of convenience of display. However, these surfaces need not have any thickness in practice. Assume that after step S102 is completed, the route surfaces are arranged in advance before the loop of steps S103 to S107 begins.

In step S104, as described previously, the visibility of the guiding route is quantitatively evaluated by calculating the visibility of each route surface.

For example, this evaluation uses viewpoint entropy E indicated by

$$E=-\Sigma i((\text{Area\_i}/\text{Area\_t})\times\log2(\text{Area\_i}/\text{Area\_t})) \quad (3)$$

where Area_i (i > 0) is the projected area of an ith

route surface, Area_t is the area of the whole

information map, and the suffix i is increased from 0

to the total number of route surfaces. Also, Area_0 is

a special value represented by equation (4) below, and

5   is an initial value corresponding to the background

area.

$$Area\_0 = Area\_t - \Sigma i(Area\_i) \qquad\qquad (4)$$

In equation (3), the projected area Area_i of

the route surface increases as the angle between a

10   line-of-sight vector (a vector from the viewpoint to

the gazing point) and the normal vector of the route

surface increases. Accordingly, a stairway or

escalator included in the guiding route is evaluated to

be easiest to see when this portion is viewed from the

15   side. Other portions are evaluated to be easiest to

see when they are viewed from above. This strategy is

based on the consideration that a two-dimensional line

can be understood most easily when it is viewed from

above, and a line including ups and downs can be

20   understood most easily when it is viewed from the side.

Also, since Area_i increases as the distance between

the viewpoint position and route surface decreases,

evaluation is made such that the closer a portion to

the viewpoint, the more easily the portion is seen.

25   Furthermore, Area_i decreases when the route surface is

obstructed by an obstacle or upper floor. Therefore, a

viewpoint position from which the line of the whole

guiding route can be well seen is evaluated to give higher visibility. As described above, the viewpoint entropy E of equation (3) is an evaluation value well reflecting the reality. Accordingly, it is possible by using this value to accurately determine a viewpoint at which ups and downs of a guiding route can be readily understood, and a viewpoint at which a guiding route is not obstructed by any upper floor.

Note that in equation (3), not only a route connecting floors but also a route surface having an effective landmark in route guidance may also be multiplied by α ($\alpha > 1$).

In step S105, the thus obtained viewpoint entropy E is compared with another one calculated from another viewpoint position candidate. If a maximum viewpoint entropy is obtained at this point, the viewpoint position and gazing position are recorded in step S106.

In step S107, whether the processes in steps S103 to S106 are completely performed for all the viewpoint position candidates is determined. If a viewpoint position candidate remains, the flow returns to step S103 to select a new viewpoint position. If all the viewpoint position candidates are completely processed, the flow advances to step S108.

In the step S108, the information map generating unit 9 generates an information map such as a precinct information map. FIG. 15 shows an example of the

processing sequence of generating this precinct
information map.

In the first step S301, the three-dimensional
shape of the guiding route is defined. For example,
this three-dimensional shape can be defined by using
line segments, or the route itself may also be
three-dimensionally defined by using circular columns
or semicircular columns. Alternatively, the whole
route can be defined after approximating it with spline
curves.

In step S302, the triangular mesh representing the
three-dimensional shape of the precincts and the
three-dimensional shape of the guiding route defined
in step S301 are perspectively projected onto a
two-dimensional plane by using the viewpoint and gazing
point with which the viewpoint entropy is a maximum,
thereby generating a precinct information map. In this
information map displayed on the screen, the gazing
point is positioned in the center of the information
map, and the viewpoint is positioned in a certain
portion of the normal passing the center of the
information map.

FIGS. 16A and 16B illustrate two examples of
precinct information maps. In each of FIGS. 16A and
16B, the start point of an arrow represents the
departure place, and the end point of the arrow
represents the destination.

In step S303, pieces of information serving as landmarks of guidance, such as platforms, doorways, ticket gates, ticket offices, and rest rooms, are two-dimensionally drawn on the precinct information map generated in step S302.

In step S109 of the flow chart shown in FIG. 2, the presentation unit 3 presents the information map such as a precinct information map.

As the presentation unit 3, it is possible to use various devices such as a display, a printer, a loudspeaker for voice output, and a device which communicates with a user's portable terminal.

In this embodiment as described above, the visibility of each of planes arranged along a guiding route is evaluated. This makes it possible to accurately determine a viewpoint from which ups and downs of the guiding route are readily understandable, or a viewpoint from which the guiding route is not obstructed by any upper floors.

Consequently, an information map which can be understood more easily than conventional maps can be presented in a guidance target area, e.g., the precincts of a building such as a large station or underground mall having a number of floors.

(Second Embodiment)

The second embodiment of the present invention will be described below.

FIG. 17 shows the arrangement of an information map presenting apparatus according to this embodiment.

As shown in FIG. 17, the information map presenting apparatus of this embodiment comprises an input unit 1, network storage unit 7, route search unit 4, shape storage unit 8, viewpoint selecting unit 10, shape deformation unit 5, information map generating unit 9, presentation unit 3, and controller 2. The input unit 1 is used to input a departure place and destination as objects of guidance, e.g., precinct guidance. The network storage unit 7 stores network data representing passages in the precincts or the like. The route search unit 4 searches the network storage unit 7 for a guiding route connecting the departure place and destination. The shape storage unit 8 stores polygon mesh data representing the three-dimensional shape of a guidance target area as an object of guidance in the precincts. The viewpoint selecting unit 10 selects a viewpoint position to be set in a three-dimensional model on the basis of the guiding route found by the route search unit 4. The shape deformation unit 5 deforms the three-dimensional shape of the precincts or the like stored in the shape storage unit 8, so that the guiding route is easily seen from the viewpoint position selected by the viewpoint selecting unit 10. The information map generating unit 9 generates an information map such as

a precinct information map by perspectively projecting

the three-dimensional shape of the precincts or the

like deformed by the shape deformation unit 5.

The presentation unit 3 presents a user with the

three-dimensional information map of the precincts or

the like generated by the information map generation

unit 9. The controller 2 controls the operation of

each unit.

FIG. 18 shows an example of the processing

sequence of the information map presenting apparatus of

this embodiment.

The contents of processes in steps S401, S402,

S405, and S406 are the same as steps S101, S102, S108,

and S109, respectively, shown in FIG. 2, so steps S403

and S404 will be explained below.

In step S403, the viewpoint selecting unit 10

selects and sets a viewpoint position and gazing

position. In this embodiment, any method can be used

in this step. That is, it is possible to use either

the same method as or a method different from that of

the first embodiment. Examples of the method different

from that of the first embodiment are: a method in

which a user designates a viewpoint position and gazing

position; a method in which a user designates a

viewpoint position, and the information map presenting

apparatus calculates a gazing position by a predeter-

mined method on the basis of the designated viewpoint

position; a method in which the information map
presenting apparatus calculates a viewpoint position
and gazing position by a predetermined method on the
basis of a departure place and destination; a method in
5   which, when the information map presenting apparatus is
mobile, a direction in which the screen of the
apparatus actually points is detected, and a viewpoint
position and gazing position are calculated such that
this specific direction in which the screen actually
10   points matches the same specific direction in an
information map when the map is displayed on the
screen; and a method in which, when the information map
presenting apparatus is fixed in a predetermined
portion, information of a specific direction in which
15   the screen of the apparatus actually points is held,
and a viewpoint position and gazing position are
calculated such that this specific direction in which
the screen actually points matches the same specific
direction in an information map when the map is
20   displayed on the screen.

In step S404, the shape deformation unit 5 deforms
the three-dimensional shape of the precincts stored in
the shape storage unit 8. FIGS. 19A to 26B illustrate
some examples of this deformation process. In each
25   drawing, A shows a three-dimensional shape before the
processing, and B shows a three-dimensional shape after
the processing.

Deformation shown in FIGS. 19A and 19B deletes a

portion which obstructs a guiding route from the

three-dimensional shape of precincts. In FIG. 19A, a

guiding route is made up of three portions, i.e., the

5   first floor, a staircase, and the second floor, but a

portion of the first floor and the staircase are

obstructed by the second floor. This makes it

difficult for a user to understand the line of this

guiding route. Therefore, as shown in FIG. 19B, a

10   portion which obstructs the guiding route is deleted so

that the line of the guiding route can be seen.

Deformation shown in FIGS. 20A and 20B deletes

extra floors from the three-dimensional shape of

precincts. In FIG. 20A, the third floor and first

15   basement not including a guiding route are displayed.

However, these floors are unsubstantial information for

a user. On the contrary, the third floor obstructs a

second floor portion of the route and thereby hides

substantial information. Therefore, as shown in

20   FIG. 20B, these extra floors not including the guiding

route are deleted to eliminate the complexity of

display and allow the line of the guiding route to be

clearly seen.

Deformation shown in FIGS. 21A and 21B deletes

25   extra regions from the three-dimensional shape of

precincts. In FIG. 21A, two regions not including a

guiding route, i.e., a ticket gate on the left side and

a Shinkansen ticket gate at the back are displayed.

However, these regions are unsubstantial for a user and

hide substantial information in some cases. Therefore,

as shown in FIG. 21B, these extra regions not including

5   the guiding route are deleted to eliminate the

complexity of display and allow the line of the guiding

route to be clearly seen.

Deformation shown in FIGS. 22A and 22B moves

a floor which obstructs a guiding route in the

10   three-dimensional shape of precincts, in an appropriate

direction by an appropriate amount. In FIG. 22A, a

first floor portion and staircase portion of a guiding

route are obstructed by the second floor. This makes

it difficult for a user to understand the line of this

15   guiding route. Therefore, as shown in FIG. 22B, this

floor obstructing the guiding route is horizontally

moved so as to be shifted backward. This allows the

whole first floor portion and part of the staircase

portion of the route to be clearly seen. Moving a

20   floor backward is of course an example, so a floor can

be moved in another direction. Also, a moving

direction along which a guiding route is most clearly

seen can change in accordance with, e.g., the

positional relationship between the three-dimensional

25   shape of a guidance target area and the guiding route.

Therefore, it is also possible, without fixing a moving

direction, to evaluate a direction in which a guiding

route is most clearly seen, and move a floor in an optimum direction.

Deformation shown in FIGS. 23A and 23B rotates, at an appropriate angle around an appropriate rotational axis, a floor which obstructs a guiding route and a floor which is obstructed in the three-dimensional shape of precincts. In FIG. 23A, a first floor portion and staircase portion of a guiding route are obstructed by the second floor. This makes it difficult for a user to understand the line of this guiding route. Therefore, as shown in FIG. 23B, the second floor is rotated so as to fall backward around rotational axis 2, and the first floor is rotated so as to fall backward around rotational axis 1. This allows the whole first floor portion and part of the staircase portion of the route to be clearly seen. As the rotational axes, it is possible to use, e.g., vectors which pass by the intersections between the floors and a partial route (in FIGS. 23A and 23B, the staircase portion) connecting the floors, and which are parallel to the floors and perpendicular to the line of sight. The rotational angles of the upper and lower floors need not be the same (one rotational angle can be 0).

Deformation shown in FIGS. 24A and 24B curves a floor which obstructs a guiding route in the three-dimensional shape of precincts. In FIG. 24A, a first floor portion and staircase portion of a guiding

route are obstructed by the second floor. This makes it difficult for a user to understand the line of the guiding route. Therefore, as shown in FIG. 24B, the second floor is curved to allow the line of the guiding route to be clearly seen.

Deformation shown in FIGS. 25A and 25B rotates a floor including a guiding route far from a viewpoint in the three-dimensional shape of precincts. In FIG. 25A, the destination of a guiding route is positioned far from a viewpoint. This makes it difficult for a user to understand the route and landmarks near the destination. Therefore, as shown in FIG. 25B, the floor is rotated so that the portion positioned far from the viewpoint comes close to it. This allows the portion positioned far from the viewpoint to be clearly seen. The rotational axis can be, e.g., a vector which is parallel to the floor and perpendicular to the line of sight.

Deformation shown in FIGS. 26A and 26B curves a floor including a guiding route far from a viewpoint in the three-dimensional shape of precincts. In FIG. 26A, the destination of a guiding route is positioned far from a viewpoint. This makes it difficult for a user to understand the route and landmarks near the destination. Therefore, as shown in FIG. 26B, the floor is curved so that the portion positioned far from the viewpoint comes close to it. This allows the

portion positioned far from the viewpoint to be clearly seen.

In each of the above examples, it is also possible to use data A in a normal state, and use data B if a user dynamically gives instructions by, e.g., pressing a specific button. In contrast to this, it is further possible to use data B in a normal state, and use data A if a user dynamically gives instructions by, e.g., pressing a specific button. In either case, although in the example shown in FIGS. 19A and 19B only the portion obstructing the guiding route is deleted from the three-dimensional shape of precincts, the floor itself including this portion obstructing the guiding route may also be deleted from the three-dimensional shape of precincts (e.g., it is also possible to display data as shown in FIG. 19A in a normal state, erase the second floor portion if a user dynamically gives instructions by, e.g., pressing a specific button, and again display the second floor portion if the user dynamically gives instructions by, e.g., pressing or releasing the specific button).

Various variations are naturally possible in addition to the examples explained above.

Also, one information map presenting apparatus can include either one deformation process or a plurality of deformation processes. In the latter case, it is possible to selectively use one deformation process, or

select two or more combinable deformation processes and simultaneously perform these processes. Alternatively, a deformation process designated beforehand by a user can be selected from the plurality of deformation processes, or these deformation processes can be dynamically switched when a user gives instructions by, e.g., pressing or releasing a specific button. Furthermore, it is possible to use a deformation process selected by the information map presenting apparatus in accordance with predetermined selection standards, or to use a deformation process selected at random by the information map presenting apparatus. In addition, the information map presenting apparatus may execute a plurality of deformation processes and select one deformation process which is evaluated to give the most clear view of a guiding route.

In this embodiment as described above, the three-dimensional shape of precincts so deformed as to allow the line of a guiding route to be clearly seen can be presented.

Consequently, effective deformation can be performed in the precincts of a building such as a large station or underground mall having deep floors or a number of floors. Accordingly, it is possible to present an information map in which the line of a guiding route is clearly seen, and which can be understood more easily than conventional maps.

(Third Embodiment)

The third embodiment of the present invention will be described below. In this embodiment, a plurality of patterns of the deformation processes explained in the second embodiment are executed, an evaluation value of the visibility of each pattern is calculated, and a deformation process having the highest visibility is used.

FIG. 27 shows the arrangement of an information map presenting apparatus according to this embodiment. As shown in FIG. 27, the information map presenting apparatus of this embodiment is obtained by adding a deformation selecting unit 11 to the arrangement of the second embodiment shown in FIG. 17.

FIG. 28 is a flow chart showing the processing sequence of the information map presenting apparatus of this embodiment. This flow chart is obtained by adding processing pertaining to the deformation selecting unit 11 to the flow chart of the second embodiment shown in FIG. 18. Therefore, the contents of processes in steps S701, S702, S703, S705, S713, and S714 are the same as steps S401, S402, S403, S404, S405, and S406, respectively, shown in FIG. 18. Loop processing related to newly added steps S704 and S706 to S712 will be explained below.

As an initial process of this loop processing, the deformation selecting unit 11 selects types

(deformation candidates) of executable deformation processes (step S704). A shape deformation unit 5 deforms the three-dimensional shape of precincts in accordance with the selected deformation types, thereby generating deformed three-dimensional guiding routes (route deformation candidates) (step S705).

A viewpoint evaluation unit 6 quantitatively evaluates the visibility of each obtained route deformation candidate, and calculates an evaluation value concerning each route deformation candidate (step S706). The viewpoint evaluation unit 6 compares each obtained evaluation value with already calculated evaluation values (step S707). If a maximum evaluation value at that point is obtained, a viewpoint position, a gazing point, and the type of deformation are recorded (step S708). If no maximum evaluation value is obtained in step S707, the flow advances to step S709. If there is no already calculated evaluation value in step S707, the present evaluation value is recorded so as to be compared with the next evaluation value.

Subsequently, whether there is another deformation candidate, i.e., whether route deformation candidates are generated for all the deformation processes is checked (step S709). If it is determined that a deformation candidate remains, the precinct shape stored for evaluation is initialized (step S710), and

the processes from steps S704 to S708 are executed for this deformation candidate. On the other hand, if it is determined that all the deformation candidates are evaluated, the flow leaves the loop processing.

An information map generating unit 9 then projects, from the viewpoint position selected in step S703, the three-dimensional shape of precincts subjected to the route deformation candidate stored in step S708 and having the highest visibility, thereby generating an information map concerning a guiding route (step S713). A presentation unit 3 presents the generated information map to the user (step S714).

As described above, the precinct information map presenting apparatus of this embodiment quantitatively evaluates a deformation process with which the line of a guiding route is most clearly seen. Accordingly, an optimum deformation process can be automatically and objectively determined. As a consequence, in the precincts of a building such as a large station or underground mall having a number of floors, an information map which can be understood more easily than conventional maps can be generated and presented.

(Fourth Embodiment)

The fourth embodiment of the present invention will be described below.

FIG. 29 shows the arrangement of an information map presenting apparatus according to this embodiment.

As shown in FIG. 29, the information map presenting apparatus of this embodiment is obtained by combining the arrangements of the first and second embodiments shown in FIGS. 1 and 17, respectively.

FIG. 30 is a flow chart showing the processing sequence of the information map presenting apparatus of this embodiment. FIG. 30 is also the combination of the processing sequences of the first and second embodiments shown in FIGS. 2 and 18, respectively. That is, the contents of processes in steps S601, S602, S603, S605, S606, S607, S608, S610, and S611 are the same as steps S101, S102, S103, S104, S105, and S106, S107, S108, and S109, respectively, shown in FIG. 2. Also, the contents of a process in step S604 is the same as step S404 in FIG. 18. In this embodiment, loop processing in steps S603 to S609 related to newly added step S609 will be explained below.

In first step S603 of this loop processing, a viewpoint selecting unit 10 selects a viewpoint position from viewpoint position candidates.

In step S604, the three-dimensional shape of precincts is deformed so that the line of a guiding route is clearly seen.

In step S605, a viewpoint evaluation unit 6 quantitatively evaluates the visibility of the guiding route. In step S606, the evaluation value is compared with an evaluation value of another viewpoint position

candidate. If a maximum evaluation value is obtained
at that point, a viewpoint position and gazing position
are recorded in step S607.

In step S608, whether the processes in steps
S603 to S609 are completely performed for all the
viewpoint position candidates is checked. If a
viewpoint position remains, the flow advances to step
S609 to initialize the three-dimensional shape of the
precincts deformed in step S609. After that, the flow
returns to step S603 to select a new viewpoint
position.

If all the viewpoint position candidates are
completely processed, the flow leaves this loop
processing.

In this embodiment as described above, it is
possible to present the three-dimensional shape of
precincts so deformed that the line of a guiding route
is clearly seen.

In addition, the visibility of each of planes
arranged along the guiding route is quantitatively
evaluated. This makes it possible to accurately
determine a viewpoint from which ups and downs of the
guiding route are readily understandable, or a
viewpoint from which the guiding route is not
obstructed by any upper floors.

As a consequence, in the precincts of a building
such as a large station or underground mall having a

number of floors, an information map which can be understood more easily than conventional maps can be presented.

(Fifth Embodiment)

The fifth embodiment of the present invention will be described below. In this embodiment, the deformation process evaluation explained in the third embodiment is executed for a plurality of viewpoint positions, an evaluation value of the visibility of each deformation process at each viewpoint position is calculated, and a viewpoint position and deformation process having the highest visibility are used.

The arrangement of an information map presenting apparatus according to this embodiment is the same as shown in FIG. 27.

FIG. 31 is a flow chart showing the processing sequence of the information map presenting apparatus of this embodiment. This flow chart is obtained by adding processing pertaining to a viewpoint selecting unit 10 and viewpoint evaluation unit 6 to the flow chart of the third embodiment shown in FIG. 28. Therefore, new steps S711 and S712 are added to the flow chart shown in FIG. 28, and step S708 is changed to step S708'. Loop processing related to the newly added steps S711 and S712 will be explained below.

As in the explanation of the third embodiment, the viewpoint selecting unit 10 selects a viewpoint

position (step S704), and evaluates the visibility of each of all deformation candidates for the selected viewpoint position (steps S704 to S709).

When the visibility evaluation of all the deformation candidates for the viewpoint position is completed, whether there is another selectable viewpoint position (viewpoint position candidate), i.e., whether route deformation evaluation of all the viewpoint position candidates is completed is checked (step S711). If it is determined that a viewpoint position candidate remains, the shape of precincts stored for evaluation is initialized (step S712), another viewpoint position candidate is selected (step S703), and the processes in steps S704 to S709 are executed for this viewpoint position candidate. If it is determined that route deformation evaluation is executed for all the viewpoint position candidates, the flow leaves the loop processing.

An information map generating unit 9 then projects, from a viewpoint position (having the highest visibility) recorded in step S708', the three-dimensional shape of precincts subjected to a route deformation candidate (having the highest visibility) recorded in step S708', thereby generating an information map concerning a guiding route (step S713). A presentation unit 3 presents the generated information map to the user (step S714).

As described above, the precinct information map presenting apparatus of this embodiment quantitatively evaluates a deformation process with which the line of a guiding route is most clearly seen, for each selectable viewpoint position. Accordingly, it is possible to automatically and objectively determine which deformation process is optimum in which viewpoint position. As a consequence, in the precincts of a building such as a large station or underground mall having a number of floors, an information map which can be understood more easily than conventional maps can be generated and presented.

(Sixth Embodiment)

The sixth embodiment of the present invention will be described below.

In this embodiment, a function of selecting the type of deformation process in accordance with the size of an information map is added to the shape deformation unit 5 of the information map presenting apparatus of each of the second to fourth embodiments.

For example, when the information map presenting apparatus has a large display and can present a relatively large information map, the presentation is not complicated in many cases without performing the deformation process of deleting extra floors shown in FIGS. 20A and 20B, or the deformation process of deleting extra regions shown in FIGS. 21A and 21B.

Likewise, a far portion of the guiding route can be clearly seen in many cases without performing the deformation process of rotating a far floor shown in FIGS. 25A and 25B, or the deformation process of curving a far floor shown in FIGS. 26A and 26B.

In contrast, when the information map presenting apparatus presents an information map on a user's portable terminal, the complexity must be eliminated by positively performing the deformation shown in FIGS. 20A and 20B or 21A and 21B. Similarly, a far portion of the guiding route must be made easy to see by effectively using the deformation shown in FIGS. 25A and 25B or 26A and 26B.

In this embodiment, therefore, a shape deformation unit 5 can accurately select the type of deformation process in accordance with the size of an information map.

The size of an information map may be input from an input unit 1 by a user, or a default size may be determined in accordance with the form of presentation of the information map presenting apparatus. Alternatively, the size of an information map may be automatically determined by a controller 2 in accordance with the form of presentation.

Consequently, an information map understandable more easily than conventional maps can be presented in the precincts of a building such as a large station or

underground mall having a number of floors.

(Seventh Embodiment)

The seventh embodiment of the present invention will be described below.

In this embodiment, the information map generating unit 9 of the information map presenting apparatus of any of the first to fourth embodiments additionally has a function of adding a supplementary explanation to a partial route whose visibility evaluated by the viewpoint evaluation unit 6 does not satisfy a reference value.

For example, in FIG. 32A, a first floor portion and staircase portion of a guiding route are obstructed by the second floor, so the visibility of each of these partial routes is evaluated as low. In particular, an evaluation value of the staircase portion of the route is 0 because this portion is entirely obstructed.

In this embodiment, an information map generating unit 9 adds a supplementary explanation such as "Go upstairs" shown in FIG. 32B to a partial route, such as the staircase portion of the route described above, whose visibility evaluation value does not satisfy a predetermined reference value. This allows a user to understand the line of the guiding route.

Consequently, an information map understandable more easily than conventional maps can be presented in the precincts of a building such as a large station or

underground mall having a number of floors.

(Eighth Embodiment)

The eighth embodiment of the present invention will be described below.

In this embodiment, the information map generating unit 9 of the information map presenting apparatus of any of the first, second, and fifth embodiments additionally has a function of generating information maps split from the start point or end point of a partial route whose visibility evaluated by the viewpoint evaluation unit 6 does not satisfy a reference value.

For example, in FIG. 33A, a first floor portion and staircase portion of a guiding route are obstructed by the second floor, so the visibility of each of these partial routes is evaluated as low. In particular, an evaluation value of the staircase portion of the route is 0 because this portion is entirely obstructed.

In this embodiment, an information map generating unit 9 generates a plurality of information maps split from the start point or end point of a partial route, such as the staircase portion of the route described above, whose visibility evaluation value does not satisfy a predetermined reference value. This allows a user to clearly see the line of the guiding route. For example, in FIG. 33B, two information maps split from the end point of the staircase portion of the route are

generated.

Consequently, an information map understandable more easily than conventional maps can be presented in the precincts of a building such as a large station or underground mall having a number of floors.

Note that each of the above functions can be implemented as software.

Note also that the present invention may also be practiced as a program for allowing a computer to execute a predetermined means (or allowing a computer to function as a predetermined means, or to implement a predetermined function), or as a computer-readable recording medium recording the program.

The arrangement explained in each embodiment of the present invention is merely an example, so any arrangement other than those described above is not excluded. It is also possible to make another arrangement by replacing part of any of the explained arrangements with another component, omitting part of the arrangement, adding a function or element to the arrangement, or combining any of these replacement, omission, and addition. Another arrangement logically equivalent to any of the explained arrangements, another arrangement including a portion logically equivalent to any of the explained arrangements, and another arrangement logically equivalent to the main parts of any of the explained arrangements are also

possible. Furthermore, another arrangement which achieves an object identical or similar to that of any of the explained arrangements, and another arrangement which achieves an effect identical or similar to that

5   of any of the explained arrangements are possible.

Various variations of the individual components explained in the embodiments of the present invention can be practiced as appropriate combinations.

The embodiments of the present invention include

10   inventions according to various standpoints, stages, concepts, and categories. Examples are an invention as a discrete apparatus, an invention of two or more related apparatuses, an invention as a whole system, an invention of an internal component of a discrete

15   apparatus, and inventions of methods corresponding to these inventions.

Accordingly, inventions can be extracted, regardless of the explained arrangements, from the contents disclosed in the embodiments of the present

20   invention.

The present invention is not limited to the embodiments described above, and can be various modified within the technical scope of the invention. It is also possible to implement the processing in the

25   embodiments as a computer-executable program, and implement this program as a computer-readable storage medium. This storage medium can take any storage form

as long as the medium can store the program and can be read by a computer. Examples are a magnetic disk, flexible disk, hard disk, optical disk (e.g., a CD-ROM, CD-R, or DVD), magneto-optical disk (e.g., an MO), and

5   semiconductor memory.

Also, on the basis of designations by a program installed from the storage medium to a computer, an OS (Operating System) or database management software running on the computer, or MW (middleware) such as a

10   network, can execute part of each processing for implementing the present invention.

Furthermore, the storage medium of the present invention is not limited to a medium separated from a computer, but includes a storage medium which downloads

15   a program transmitted across, e.g., a LAN or the Internet and stores or temporarily stores the program.

Also, the number of storage media is not limited to one. That is, the storage medium of the present invention includes a case in which a plurality of media

20   execute each processing of the present invention. In this case, each storage medium can take any of the above-mentioned forms.

A computer of the present invention executes each processing on the basis of the program stored in the

25   storage medium. This computer can be, e.g., a single apparatus such as a personal computer, or a system in which a plurality of apparatuses are connected across a

network.

Furthermore, a computer of the present invention is not limited to a personal computer but includes an arithmetic processing unit included in an information processing apparatus, a microcomputer, and the like. That is, a computer of the present invention is a general term for apparatuses and devices capable of implementing the functions of the embodiments.

Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the spirit and scope of the general inventive concept as defined by the appended claims and their equivalents.